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URS METHODOLOGY – A TOOL FOR STIMULATION OF ECONOMIC GROWTH BY INNOVATIONS

by

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Abstract. The paper introduces a new methodology for evaluation of innovations. It is based on the notion of utility, depending on the capital rate of return and safety. Safety is defined as the notion complementary to the value at research risk (VaR). The value at safety (VaS) is an increasing function of research and development period (T). The methodology enables one to derive the optimum utility maximizing T and a ranking of innovation projects. The stimulation of economic growth by innovation is also studied.

Key words: innovations, evaluation of R&D projects, utility function investments, research risk, capital return, safety, financial and organizational leverages, joint venture contracts.

1. Introduction. There is a growing interest among investors and managers to understand the advantages of innovations in order to employ and exploit them in business activity, if necessary. It is believed that innovations determine the competitiveness, i.e. comparative advantages of firms competing on the market and that they pave the road to success. Indeed, in the era of globalisation capital is flowing to those regions, sectors of economy and firms, which offer bigger utility for the investors. Each innovation can be evaluated from the point of view of expected capital return and risk involved. In the case of investment based on innovation, besides the standard risk components, such as business and financial risk, there is, as well, the research and development risk present. The resulting risk determines also the investor's perception of safety attached to the innovation. The safety is a notion, which is contrary to the risk. Expected capital return R and safety S can be therefore regarded as the main factors of utility U(R, S). Deriving R, S and the utility U, for the specific innovation project, one gets a measure of value of the firm introducing and exploiting innovation. Such a firm generally belongs to the category of "growth firms". A growth firm is characterised [1] by the relation R>r, where r=capitalization rate (used for discounting future net operating income). These firms maximize their value by retaining all earnings for internal investments. The rest of the firms is classified as normal (R=r) or declining (R<r). Such a classification is not permanent. Each declining firm becomes a growth firm introducing innovations and a growth firm becomes declining when it exploits the innovation. A simple ex post measure of the competitiveness of an economy (in macro) is the weighted percentage of the number of growth firms in the whole set of firms.

On the micro level the innovation is, for an investor, a risky commitment so he prefers to evaluate competitiveness in the ex ante sense rather. Such an approach is advocated in the so-called fundamental analysis, see e.g. [1]. Using such an approach the investors before each transaction evaluate shares of the firms listed on the stock exchange. It should be, however,

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observed that application of fundamental analysis to growth (innovative) firms is not easy. The problem requires, in particular, discounting future cash flow, which is declining in time as a result of declining demand for ageing products.

Then the expected return R depends on the cost of investment (carried on in the investment period T) and the "harvesting" period $T_h=T_l-T$, where T_l=time when the cash flow of selling is zero. The bigger is T_h/T, and product profit rate, the bigger is R. In RSU methodology the research risk and safety, expressed by the rate of research progress, are derived by the two scenarios model. The URS methodology is a tool to support computation of R, S and U. It enables one the ranking or selection of concrete investment projects. The methodology was developed and described in the number of papers [2-7].

In the present paper one describes shortly URS methodology and model of innovation activities. The efficiency of research and innovations, are also analysed. It is shown that the managers can control efficiency of innovations, which requires a concentration of human and financial capital in the short period T, by three main levers: basic research, organisational and financial.

It is believed that URS methodology, helps managers and investors to evaluate and choose the best, out of a set of alternative innovations and to make the chosen innovation effective. Though, in the present paper, the application of URS methodology was limited to the innovations on micro level mostly it can be extended to macro systems as well. It can be regarded therefore as a tool for stimulation of economic growth by the use of innovations.

2. URS methodology. RSU methodology is a tool for supporting present decisions, which result (in future), in uncertain consequences.

The methodology deals with utility U based on the expected rate of return R and safety S, i.e. a notion, which is opposite to the risk.

In the present section main concepts (described in details in Ref [2-7]) of URS methodology will be given.

For that purpose assume that one invests at t=0 the capital $P(0)=P_0$, expecting to get at t=1 the capital $P_1=P(1)>P_0$. The return $\tilde{R}=\frac{P_1-P_0}{P_0}$ is a random, normally distributed variable with given expected value $R=E\{\tilde{R}\}$ and the variance σ^2. The decision-maker (i.e. the investor) is interested in two monetary values:

1. expected monetary return $Z=P_0R$,
2. worse cases or-net monetary return $Y=P_0[R-\kappa\sigma]$, where κ can be called the "price of fear" of the worse case consequences.

Introducing the popular recently notion of "value at risk", i.e.

$$VaR=P_0\,\kappa\,\sigma \tag{1}$$

and the complementary notion of "value at safety":

$$VaS=P_0RS, \quad S=1-\kappa\frac{\sigma}{R}, \tag{2}$$

one gets

$$VaR+VaS=VaE, \tag{3}$$

where VaE is the expected value $VaE=P_0R$.

The parameter κ can be also interpreted as a quantile of the normal probability distribution, shown in Fig. 1. The value RS= Y /P_0 splits the range of $\widetilde{R}$ on two subsets with the probabilities:

$$Pr\{\ \widetilde{R} \le R - \kappa_p \sigma\ \} = p$$
$$Pr\{\ \widetilde{R} \ge R - \kappa_{1-p} \sigma\ \} = 1 - p$$

The numerical values of κ_p for a given p can be easily derived using tables of normal p.d.f. E.g. $\kappa_{0,025} \approx 1{,}96$, $\kappa_{1/6} \cong 1$, etc. [8].

One should observe that the index S, called in [2-7] the index of safety or assurance, has a practical meaning for the investments, which are acceptable by the investor. Namely it should offer the investor a premium for bearing the risk, i.e. $R \ge R_F + \kappa\sigma$, where R_F is a return on risk-free investments (e.g. government bonds). The S is a positive number $S \in (0{,}1]$. One can see also, by (3), that an increase (decrease) of VaR requires a decrease (increase) of VaS.

In order to evaluate the utility of an investment the decision-maker has to introduce a suitable utility function. The concept of single factor utility (F(z)) was introduced in economic sciences long ago. That function was axiomatically justified in the well-known paper by von Neumann and Morgenstern (1949). It was, however, criticised by some economists (I. Fisher, M. Allais), who argued that people make decisions using the expected values as well as the variances σ^2. For these reasons instead of single factor utility in the papers [2-7] the concept of two factors-utility function, was introduced.

The first factor is $NVaE = P_0 RN$, where N is generally the ratio n/n_0 of number n of shares (of an investment), e.g. shares of stock, over the investor's total assets (expressed by number n_0) with the price P_0 each. When a split of shares takes place the product of earnings by share $(P_0 R)$ and N does not change.

The second

$$VaS = P_0 R\left(1 - \kappa\frac{\sigma}{R}\right) = P_0 RS.$$

Then the utility function becomes

$$U = F[NVaE, VaS] = F[P_0 RN, P_0 RS].$$

Since both factors are expressed in monetary values the function F should be "constant return to scale". Otherwise it would change, when one changes monetary units (e.g. US$ to 100 cents). The simplest function of required type is the Cobb-Douglas function, i.e.

$$U = (P_0 RN)^{\beta}(P_0 RS)^{1-\beta},\ S \in (0{,}1],\ \beta \in [0{,}1]. \tag{4}$$

The function (4) increases along with R and S, as well as, number N. One can observe that utility (4) is expressed in monetary terms. It attains the maximum value for S=1. When one invests in a stock with expected return $P_0 R$ [US$] the utility at S=0.8 and $\beta = 0.5$ is only 0.89 $P_0 R$ [US$]. Then the factor $S^{1-\beta}$ discounts the expected value $(P_0 R)$ in the presence of a risk or thread. An increase of U along with N is negatively accelerated as in the case of classical single factor utility.

Using (4) it is possible to plot the constant utility curves on the R(S) plane. These curves are described by the function

$$R = \overline{U} / S^{1-\beta}, \text{ where } \overline{U} = U / P_0 N^{\beta} = const.$$

In many risk management problems the return R and safety S depend parametrically on a control parameter x. Then the problem of choosing optimum strategy $x = \hat{x}$ can be formulated as the problem of finding the tangent point of a constant utility curve to the plot of $R(x)[S(x)]$. An example of such a procedure, illustrated by Fig. 2, will be given in the next section. It is assumed that R(S) is strictly concave, decreasing. Then the strategy $\hat{x}$ exists and is unique. One can also assume that $\{R,S\}>0$. Then one can also derive $\hat{x}$ formally by the condition

$$\delta U = \delta R + (1-p)\delta S = 0\,, \tag{5}$$

where $\delta U = \dot{U}/U$; $\delta R = \dot{R}/R$; $\delta S = \dot{S}/S$ are small increments. The condition (5) can be written also in the form

$$\frac{S(x)}{R(x)} = \frac{1-\beta}{\omega(x)}, \tag{6}$$

where $\omega(x) = -\frac{dR}{dx} : \frac{dS}{dx}$ is marginal rate of substitution.

Using (6) one can also construct an interactive algorithm for deriving $\hat{x}$ strategy [6].

It should be observed that in order to use the URS-methodology one should get the numerical values for the subjective parameters (κ and β). In capital investment problems κ is usually assumed around 0.5~2, see also [2-7]. For determining β assume that R and S are constant, while P_0 and N get the small increments $\delta P_0 = \dot{P}_0 / P_0$; $\delta N = \dot{N}/N$. Then one gets by (4) $\delta U = \delta P_0 + \beta \delta N = 0$ or $\beta = -\delta P_0 / \delta N$. One can imagine that an offer of the stock seller is made to sell $N\,(1+\delta N)$ stocks at a decreased price $P_0(1-\delta P_0)$each. If the buyer accepts the transaction one can assume that his utility is characterised by $\beta = -\delta P_0 / \delta N$. If e.g. the decrease of price by 0.5 % is achieved by the increase of number of stocks bought by 1 %, one gets β=0.5.

The URS-methodology enables one also to set a simple rule of acceptance of projects characterised by given set $\{R_i, S_i\}, i = 1, 2 \ldots$. Indeed, the investor will accept a project only in the case, when it offers him utility $U(R_i, S_i) = P_i R_i S_i^{\,1-\beta}$ at least equal the utility of risk-free investment$U(R_F, 1) = P_i R_F$. Then the accepted project return should satisfy the following condition:

$$R_i \geq \frac{R_F}{S_i^{\,1-\beta}}, \; i = 1, 2 \ldots. \tag{7}$$

3. Model of innovation activities. In order to apply the URS-methodology to the $R\,\&\,D$ systems it is necessary to construct a model of research and development activity. One can assume that research is carried on in the form of research projects. Each project is aimed to achieve certain goal, starting with very simple, such as: answer a question or solve a problem, to more complicated theoretical problems, such as: construct a theory or a model, explaining the physical, biological, economic etc. phenomena. There are also applied problems, such as: construct new materials, technologies or prototypes of new machinery, computers (hard and soft version) etc. There are, as well, very complicated projects, such as Manhattan project or "put a man on the moon" etc.

Each project requires resources concentrated within the time T, to finish the investment and start selling innovative product. Each project is evaluated from the point of view of expected return R and, according to URS-methodology from the point of view of the measure of safety, which is regarded as synonym of success (S). It is a notion complementary to the risk of failure. From the URS point of view T is the main control parameter, which should be chosen in such a way that utility U(R, S) is maximum.

First of all one should consider two scenarios of research accomplishment:

1. success: return $R(T) = R^u$ is attained with probability $1 - p(T)$,
2. failure: return $R(T) = R^d$ is attained with probability $p(T)$.

The return $R^u = \frac{P_1(T,T_1)}{P_0(T)} - 1$, where $P_0(T)$ is the present value of continuously discounted investment, i.e. human and financial capital costs, which flow with the rate P_0/year:

$$P_0(T) = \int_0^T P_0 e^{-rt} dt = \frac{P_0}{r}\left(1 - e^{-rt}\right), \text{ r=discount rate.}$$

$P_1(T,T_1)$ is the present value of cash flow, within the harvesting period $[T, T_1]$, which due to product ageing with the given rate r_a becomes:

$$P_1(T,T_1) = \int_0^{T_1-T} P_1 e^{-r_a(T+t)} dt = \frac{P_1}{r_a} e^{-r_a T}\left[1 - e^{-r_a(T_1-T)}\right];$$

$P_1 e^{-r_a T}$ is the cash value, when the selling of innovated product starts. Then

$$R^u = \pi \frac{e^{-r_a T}\left[1 - e^{-r_a(T_1-T)}\right]}{1 - e^{-rT}} - 1, \quad \pi = \frac{P_1 r}{P_0 r_a}.$$

It is possible to observe that for a fixed T, R^u as the function of T_1, decreases exponentially, along with growing of the harvest period $T_h = T_1 - T$, so in many cases it can be approximated by the function depending on T only:

$$R^u(T) = \pi \frac{e^{-r_a T}}{1 - e^{-rT}} - 1 \tag{8}$$

Obviously, in real situations, in order to survive, the innovative firm should start selling a new innovative product not later than T_1.

In the case of failure $P_1=0$ and $R^d = -1$.

One can also show that probability of success $1 - p(T)$ increases along with T, while probability of failure p(T) decreases. For that purpose assume that the research takes the form of x trials, tests or experiments, each taking a specific or basic period of time ΔT and characterized by the perceived (by researchers) probability of success q and probability of failure 1-q. Using the Bernoulli scheme one can drive the probability of success after x failures, which is the geometric probability density function

$$\bar{p}(x) = q(1-q)^x, \quad x = 0, 1, 2...; \; 0 < q < 1 \tag{9}$$

The expected value of (9), see e.g. [8], is
$E(x) = (1-q) : q$,

while the variance $V(x) = \frac{1-q}{q^2}$.

One can also derive the cumulative probability distribution

$$1 - (1-q)^{x+1}, \quad x = 0, 1, 2.... \tag{10}$$

which describes the probability that the first success appears at least after x basic periods, i.e. after the time $x\Delta T$.

The discrete distribution (9) can be approximated by the continuous function $p(T)$ of investment horizon T:

$$p(T)=\frac{\Delta T}{\tau_r}e^{-\frac{x\Delta T}{\tau_r}}=\frac{\Delta T}{\tau_r}e^{-\frac{T}{\tau_r}}. \tag{11}$$

By equalizing the $E(x)=\frac{1-q}{q}$ to the first moment of (11) one gets

$$\tau_r=\frac{1-q}{q}\Delta T, \tag{12}$$

where $\frac{1-q}{q}$ = Prob.of failure : Prob. of success is the subjectively perceived, project "degree of difficulty", ΔT represents here the research organization and efficiency of research team.

In the research institute, such as e.g. IBS PAN, it takes on average, about ½ year to get one publication/researcher in professional journals. There are, however, very efficient people, who produce 3,4 publications per year and as well people who need ΔT = 1 year or more to achieve success in publications.

The continuous version of cumulative probability of success becomes

$$1-p(T)=1-e^{-T/\tau_r}, \tag{13}$$

where τ_r can be called the "breakthrough period", i.e. the time when the ratio $[1-p(T)]:p(T)\cong 1{,}72$. The inverse $r_r=1/\tau_r$ can be called the "rate of research progress".

By (8) and (13) one can derive the expected rate of return

$$R(T)=[1-p(T)]R^u+p(T)R^d=\pi e^{-r_aT}\frac{1-e^{-r_rT}}{1-e^{-rT}}-1, \tag{14}$$

and safety index

$$S(T)=1-\kappa\frac{\sigma(T)}{R(T)}, \tag{15}$$

where

$$\sigma^2(T)=[1-p(T)][R(T)-R^u]^2+p(T)[R(T)-R^d]^2=p(T)[1-p(T)][R^u-R^d]^2,$$

and

$$\frac{\sigma(T)}{R(T)}=\left[e^{-r_aT}-e^{-2r_rT}\right]^{1/2}:\left[1-e^{-r_rT}+\frac{1}{\pi}\left(e^{-rT}-1\right)e^{r_aT}\right]. \tag{16}$$

One should observe that the safety index (15) has been derived under tacit assumption that project risk is solely the research risk, appearing within the investment period T. Within the harvesting period other components, such as business or financial risks, should be taken into account. Another way to deal with that portion of the general project risks is to discount the cash flow at a bigger rate than standard rate of aging (r_a).

NUMERICAL EXAMPLE. Evaluate the research project, characterized by: discount rate r=0.1; ageing rate $r_a=0{,}2$; research progress rate $r_r=1$ $(q=1/3, 1-q=2/3, \Delta T=1/2, \tau_r=1)$; present value profit rate $\pi=1$ $\left(P_1/P_0=2\right)$. The investor's utility is characterized by $\kappa=1, \beta=0.5$, while $R_F=0.1$.

Using formulae (14) (15) one gets:

$$R(T)=\left[e^{-0.2T}-e^{-1.2T}\right]:\left(1-e^{-0.1T}\right)-1,$$
$$S(T)=1-\left[e^{-T}-e^{-2T}\right]^{1/2}:\left[1-e^{-T}+e^{0.1T}-e^{0.2T}\right]. \qquad (17)$$

The plots of R(T) and S(T) are shown in II and IV quadrants of coordinate system of Fig. 2. Using the geometrical procedure, indicated by dotted curves one finds, for each specific value of T, the corresponding values of R(T), S(T) in the I quadrant of the coordinate system in Fig. 2. The resulting curve R(S) is concave and it has a unique tangent point (depicted by $\hat{T}=1{,}5$) to the constant utility curve $R(\tau)\sqrt{S(\tau)}=1{,}7$. Knowing the optimum planning horizon $T=\hat{T}=1{,}5$, enables one to determine the optimum return $R(\hat{T})=\hat{R}=3.132$ and safety $S(\hat{T})=0{,}294$, as well as the numerical value of utility $P_0\hat{R}\sqrt{\hat{S}}$.

One can also check, using (7), is the project acceptable, comparing it to the risk free investment, which is characterized by $R_F=0{,}1$. One gets $\hat{R}>0.1/\sqrt{0.294}=0.184$, so the project under consideration is very profitable and should be accepted. Observe, however, that when the project investment horizon T is delayed and approaches $T=4.4$; $S(T)\to 0$, while R(T) decreases, so condition (7) is violated. In such a case the project should be rejected. In other words a delay in the investment period can make the innovation project unprofitable and unacceptable.

The present example can be employed to show the application of URS methodology for decision support in investments in human capital. For that purpose consider a student who considers an application for doctoral studies. He would like to compare the utility of doctor degree, taking into account the returns (14) (with the cost P_0 and doctor wage P_1), as well as the safety (due to risk of failing in doctoral examination (15)), with other risky carrea options. Since during doctoral studies approximately half of the time T is spend on additional education the efficiency denoted by $\Delta T'$ is twice longer than ΔT. Then the research progress for doctoral studies (r'_r) with $q=\frac{1}{3}$ becomes $r'_r=0.5$, $r_r\approx 1$. Assuming also (in order to facilitate computations) $P_1/P_0=2$, $r'=0.5$, $r\approx 0.05$, $r'_a=0.5, r_a=0.1, \chi=1, \beta=0.5$ and $T'=2T$; one can see that the optimum time $\hat{T}'$(to complete the doctoral studies) becomes $\hat{T}'=2\hat{T}=3$ years, while $R(\hat{T}')=3{,}132$, $S(\hat{T}')=0.294$. Then the numerical value of utility of doctoral studies becomes $U\le P_0\hat{R}'\sqrt{\hat{S}'}=1{,}698P_0$.

Suppose the most attractive for the student career option is characterized by return R*, safety S* and utility U*=$P_0R^*\sqrt{S^*}$. Then, in order to choose doctoral studies the following relation U$\ge U^*$, i.e., $R^*\sqrt{S^*}>1{,}698$, should hold. Then the URS methodology can be also used to support individual decisions, concerning investments in professional career options.

4. Research and Innovation Efficiency. As argued in Section 3. the successful completion of an innovative project requires a concentration of research resources within a short time interval T. To achieve such a concentration of human and financial capital three kinds of controls, called levers, can be used.

Basic research, carried on in the research institutes and universities, is the most important kind of leverage denoted by L_b. It supports creativity and decreases failure/success probability ratio $\frac{1-q}{q}$, which in turn increases research progress rate r_r.

In order to evaluate L_b one can use the well-known Bayes formula for the posterior probability of success (S):

$$P_r(S/B)=\frac{P_r(B/S)P_r(S)}{P_r(B)},$$

where $P_r(B/S)$ characterizes the share of the projects levered (by employing basic research B) among the successful projects, while $P_r(B)$ characterizes the share of levered projects among all projects involved (i.e. levered and unlevered).

Denoting the a priori (i.e. unlevered) probability of success $P_r(S)$ by q_0, one gets for the posterior probability of success $q=L_b q_0$, where $L_b=P_r(B/S):P_r(B)$.

As an example, assume that the share of projects supported (levered) by basic research among the successful project is $P_r(B/S)=1/2$, while $P_r(B)=1/4$. Then the basic research leverage $L_b=2$, i.e. the employment of basic research in the project has increased twice the probability of success, i.e. $q/q_0=2$.

Since in many situations the financing of basic research is institutionally detached from the production the impact of L_b-leverage on innovations is not evident. One can, however, observe that innovations are created by high quality human capital, which is inspired by basic research. Without high quality of basic research there are no innovations possible. It is also obvious that a country, which wants to grow by innovations, should not save on basic research expenditures.

The second is human or organizational leverage. When a team of researchers is working on a project the rate of research progress r_r can be increased (and the research risk σ_r reduced) by increasing the human capital engaged in the project. That, however, requires an increase of team staff and corresponding increase of cost P_0. As a result the safety S of the project increases at the expense of reducing the expected rate of return R.

The organizational leverage consists in choosing the size of the research team, and an efficient project organization, in such a way that the resulting utility is maximum. The project organization requires that the general research goal is split into subgoals or operations, performed in sequence or parallel in time, according to the so-called PERT graph. The resources allocated to the specific operations should be chosen in such a way that utility is maximized by changing the number n of researchers. To solve that problem effectively one can use URS methodology interactively i.e. by repeating the optimization procedure, illustrated by the numerical example in Sec 3, with increasing at each step the number n up to the state when the utility starts to decline. Suppose that by increasing the human capital engaged in the project one can increase y times the research progress rate. The levered rate becomes $r_r{}'=yr_r{}''$, where $r_r{}''$=unlevered progress rate, while y factor can be called organizational leverage control. Introducing organizational leverage one can reduce the research risk at the expense of increasing P_0, which becomes

$$P_0'=P_0''+C(y),\quad y\geq 1,$$

where C(y) is monotonically increasing function of human capital engaged and C(1)=0.

One can also say that increasing leverage factor y the R(y) declines at the expense of growing safety S(y).

The third control is the financial leverage. It is used by corporations mostly which want to increase return R_e on equity (E) by introducing financial debt D. One can show [7] that

$$R_e = R_i + \left[R_i - \left(1 - T_p\right)r\right]\frac{D}{E},$$

where $R_i = Z:(E+D)$ is the return on investments, Z=net operating income, T_p=corporation tax, r=cost of capital.

Obviously $R_e > R_i$ (when $R_i > (1-T_p)r$), but at the same time the financial risk (σ_f) increases along with leverage control $x = D:(D+E)$. In order to avoid bankruptcy corporations do not increase x above $0.4 \div 0.6$. As a result of financial leverage the return $R_e(x)$ increases at the expense of decreasing safety index S(x). In [5] the optimum strategy $x = \hat{x}$, maximizing utility of the form (4) was derived.

5. Matching financial and human capital. In large corporations, which have their own research divisions, the decision-maker can operate all the levers in order to achieve effective concentration of resources and maximize the corporation utility. In order to evaluate any new innovation one can apply here the URS methodology, which enables calculation of the optimum development time $T = \hat{T}$ and the corresponding return $R(\hat{T})$ and safety $S(\hat{T})$. Then one can easily check, using (7), is the innovation profitable for the corporation development. However in some countries, like Poland, most of research institutes and production firms are detached institutionally and organizationally. Separately they lack the financial ar human capital (or both) and they can not achieve concentration of capital, necessary to undertake the innovating projects and come on the market with a competitive products fast. Due to low research budget there is no incentive in the research institutes to undertake the risk of finishing the projects fast. Much easier one can get on, writing second rated papers, which at the final stage of preparation are use to formulate a planned problem for the next year to come. Using such a practice there is no risk of failure. As a result, however, a lot of human capital is idling. On the productive side of the existing traditional system, many firms have problems with collecting capital necessary for innovations. They believe there is little chance to get in a short time the domestic research products so they prefer to stick to the traditional production. The traditional production, however, has no chance to compete on the market with modern products. So the traditional production declines and so are doing the traditional firms. That gloomy outlook is aggravated by the fact that domestic human capital is ageing and declining due to emigration and the lack of innovations to undertake research career by young people. Many of them believe that egalitarian policy in wages does not stimulate creative people to undertake ambitions, but low paid research work.

Some people ask the question: can the country, which has a declining human capital survive in the competitive world by embarking on a ship, call innovations? Since the country has nothing else to embark on the answer is usually positive. However, when one wants to embark he has to evaluate ex ante each innovation and choose the most effective one. Innovation, which are not profitable should be rejected ax ante rather than ex post. On the macro level new policy and some system reforms are necessary to pave the road to success of innovations. In particular:

1. the stock of human capital should be prevented from decline . That can be done by improving creativity by education and better coordination of basic research carried mostly on in the institutes of PAN, MEN etc.
2. it is necessary to encourage and motivate scientists to undertake ambitions external applied projects and compensate their effort for carrying the research risk. It can be implemented e.g. by budget giving the director of research institute a fund for awards and claims. The awards should be promised to those scientists who undertake important and risky projects. Awards should be paid in the case of success achieved in the time set by external contracts only. In case of failure awards should be used to compensate the claims of external contracts.
3. when a joint-venture contract between a research institute and productive firm is signed to undertake an innovative project the project return, safety and utility of both parties should be calculated (one can use here the URS methodology). The contract should clearly specify the participation in common costs and profits, according to the partners utilities and Nash equilibrium principle (see e.g. [7]). The Nash principle can help also in reaching agreement in negotiations between the partners involved in the project, if necessary.
4. efforts should be made to create an efficient market for innovations. So far such a market practically does not exists. Potential producers of innovations are not informed on domestic research achievements and vice versa. The researchers do not know the needs and capabilities of producers. Many tenders on research contracts are biased and subject to corruption. There is therefore a demand to create a "stock of information exchange" using e.g. internet, special publications, exhibitions, prelections etc. sponsored and supervised by research and business organizations. It should be also noted that reforms stimulating innovations in market economy can not be enforced or implemented by law solely. In that economy two rules should be respected:
   - the capital will reinforce the innovation which promises return large enough for the risk involved, only
   - the researchers will implement any feasible innovation proposal if they are paid enough (i.e. if they get a return large enough for the research risk involved).

     These two rules do not work automatically in polish economy due to the fact that there is no real market for innovations. Before such a market will emerge it is necessary to organize the matching services, which can be called "Innovations Promoting Agency". The IPA could e.g.:
   - evaluate potential innovation proposals in order to:
     - select the feasible projects,
     - derive the optimum research time horizon $\hat{T}$ and the corresponding return, safety, utility,
     - construct ranking of innovation proposals,
   - disseminate the evaluation results among the production, business organizations, research institutes, regional authorities etc.,
   - collect and organize negotiations (between partners interested in implementation of innovations) in order to sign the joint venture innovative contracts.
5. the practice of innovation projects evaluation, ranking and selection is generally on very low level, despite the fact that in recent years there is considerable advance in evaluation methodology social choice, computerized support systems etc. The continuous education program for research administration, organized

by competent people who understand modern methodology and know from practice how the research and innovations work could probably help to improve the present situation.

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